1.4 MOULDING MATERIAL AND PROPERTIES

A large variety of molding materials is used in foundries for manufacturing molds and cores. They include molding sand, system sand or backing sand, facing sand, parting sand, and core sand. The choice of molding materials is based on their processing properties. The properties that are generally required in molding materials are:

Refractoriness

It is the ability of the molding material to resist the temperature of the liquid metal to be poured so that it does not get fused with the metal. The refractoriness of the silica sand is highest.

Permeability

During pouring and subsequent solidification of a casting, a large amount of gases and steam is generated. These gases are those that have been absorbed by the metal during melting, air absorbed from the atmosphere and the steam generated by the molding and core sand. If these gases are not allowed to escape from the mold, they would be entrapped inside the casting and cause casting defects. To overcome this problem the molding material must be porous. Proper venting of the mold also helps in escaping the gases that are generated inside the mold cavity.

Green Strength

The molding sand that contains moisture is termed as green sand. The green sand particles must have the ability to cling to each other to impart sufficient strength to the mold. The green sand must have enough strength so that the constructed mold retains its shape.

Dry Strength

When the molten metal is poured in the mold, the sand around the mold cavity is quickly converted into dry sand as the moisture in the sand evaporates due to the heat of the molten metal. At this stage the molding sand must posses the sufficient strength to retain the exact shape of the mold cavity and at the same time it must be able to withstand the metallostatic pressure of the liquid material.

Hot Strength

As soon as the moisture is eliminated, the sand would reach at a high temperature when the metal in the mold is still in liquid state. The strength of the sand that is required to hold the shape of the cavity is called hot strength.

Collapsibility

The molding sand should also have collapsibility so that during the contraction of the solidified casting it does not provide any resistance, which may result in cracks in the castings. Besides these specific properties the molding material should be cheap, reusable and should have good thermal conductivity.

TESTING SAND PROPERTIES

The moulding sand after it is prepared, should be properly tested to see that the requisite properties are achieved. These are standard tests to be done as per Indian Standards.

Sample Preparation

Tests are conducted on a sample of the standard sand. The moulding sand should be prepared exactly as is done in the shop on the standard equipment and then carefully enclosed in a container to safeguard its moisture content.

Moisture Content

Moisture is an important element of the moulding sand as it affects many properties. To test the moisture of moulding sand a carefully weighed sand test sample of 50g is dried at a temperature of 105^0 C to 110^0 C for 2 hours by which time all the moisture in the sand would have been evaporated. The sample is then weighed. The weight difference in grams when multiplied by two would give the percentage of moisture contained in the moulding sand. Alternatively a moisture teller can also be used for measuring the moisture content. In this sand is dried by suspending the sample on a fine metallic screen and allowing hot air to flow through the sample. This method of drying completes the removal of moisture in a matter of minutes compared to 2 hours as in the earlier method.

Another moisture teller utilizes calcium carbide to measure the moisture content. A measured amount of calcium carbide (a little more than actually required for complete reaction) in a container along with a separate cap consisting of measured quantity of moulding sand is kept in the moisture teller. Care

has to be taken before closing the apparatus that carbide and sand do not come into contact. The apparatus is then shaken vigorously such that the following reaction takes place:

$$CaC_2 + 2\ H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

The acetylene (C_2H_2) coming out will be collected in the space above the sand raising the pressure. A pressure gauge connected to the apparatus would give directly the amount of acetylene generated which is proportional to the moisture present. It is possible to calibrate the pressure gauge directly read the amount of moisture.

Clay Content

The clay content of the moulding sand is determined by dissolving or washing it off the sand. To determine the clay percentage a 50 g sample is dried at 105 to 110^0 C and the dried sample is taken in a one litre glass flask and added with 475 ml of distilled water and 25ml of a one percent solution of caustic soda (NaOH 25 g per litre). This sample is thoroughly stirred.

After the stirring, for a period of five minutes, the sample is diluted with fresh water up to a 150 mm graduation mark and the sample is left undisturbed for 10 minutes to settle. The sand settles at the bottom and the clay particles washed from the sand would be floating in the water. 125 mm of this water is siphoned off the flask and it is again topped to the same level and allowed to settle for five minutes. The above operation is repeated till the water above the sand becomes clear, which is an indication that all the clay in the moulding sand has been removed. Now, the sand removed from the flask and dried by heating. The difference in weight of the dried sand and 50g when multiplied by two gives the clay percentage in the moulding sand.

Sand Grain Size

To find out the sand grain size, a sand sample which is devoid of moisture and clay such as the one obtained after the previous testing is to be used. The dried clay free sand grains are placed on the top sieve of a sieve shaker which contains a series of sieves one upon the other with gradually decreasing mesh sizes. The sieves are shaken continuously for a period of 15 minutes. After this shaking operation, the sieves are taken apart and the sand left over on each of the sieve is carefully weighed. The sand retained on each sieve expressed as a percentage of the total mass can be plotted against sieve number. But more important is the Grain Finesses Number (GFN) which is a quantitative indication of the grain distribution. To calculate the GFN each sieve has been given a weightage factor as given in the Table –IV. The amount retained on each sieve is multiplied by the respective weightage factor, summed up and then divided by the total mass of the sample, which gives the GFN.

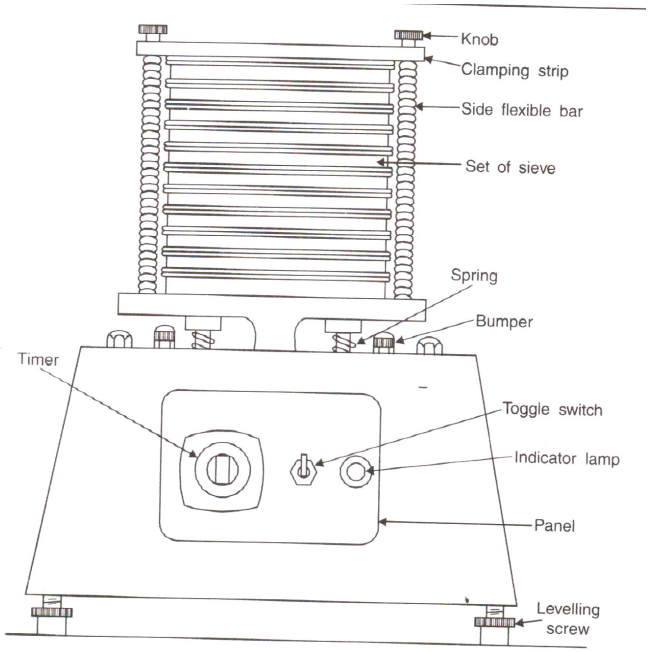

Figure 1.4.1: Sieve shaker

Mathematically

$$\text{GFN} = \frac{\sum M_i f_i}{\sum f_i}$$

Where M_i = multiplying factor for the i_{th} sieve
f_i = amount of sand retained on the i_{th} sieve

US Series Equivalent No. (ASTM)	Mesh Opening(mm)	IS Sieve No. Microns	Multiplying Factor
6	3.327	3.35	3
12	1.651	1.70	5
20	0.833	850	10
30	0.589	600	20
40	0.414	425	30
50	0.295	300	40
70	0.208	212	50
100	0.147	150	70
140	0.104	106	100
200	0.074	75	145
270	0.053	53	200
PAN	-	-	300

Table-IV: AFS Sieve Numbers and Their Indian Equivalents with sizes

A typical example is presented in Table-V for calculation of GFN.

Sieve Number	Multiplying Factor, M_i	Retained Sample, f_i (g)	Retained Percentage P_i	M_i x P_i	$-M_i$ x f_i
40	30	2.495	5	150	74.85
50	40	13.972	28	1120	558.88
70	50	23.952	48	2400	1197.60
100	70	6.986	14	980	489.02
140	100	2.495	5	500	249.50
		49.900	100	5150	2569.85

Table-V

$$\text{GFN} = \frac{\text{Mi x Pi}}{\text{Pi}} = \frac{5150}{100} = 51.50$$

$$= \frac{\text{Mi x fi}}{\text{fi}} = \frac{2569.85}{49.90} = 51.50$$

GFN is the average grain size and corresponds to a sieve number through which all the sand grains would pass through, if they were all of the same size. GFN value varies between 40 and 220 for those sands used by most of the foundries. Though the sand properties depend on both the grain size and the grain size distribution, GFN is a very convenient way of finding the sand properties since it takes both into account.
Example: GFN 41 : steel castings 50 Kg and more
67 : Small steel castings
105: Light cast iron and copper castings
150: Aluminium alloy castings

Permeability

The rate of flow of air passing through a standard specimen under a standard pressure is termed as permeability number. The standard permeability test is to measure time taken by a 2000 cm^3 of air at a pressure typically of 980 Pa to pass through a standard sand specimen confined in a specimen tube. The standard specimen size is 50.8 mm in diameter and a length of 50.8 mm. Then, the permeability number, P is obtained by

$$\mathbf{P} = \frac{V \times H}{p \times A \times T}$$

Where V = volume of air = 2000 cm^3

H = height of the sand specimen = 5.08 cm

p = air pressure, g/cm^2

A = cross sectional area of sand specimen= 20.268 cm^2

T = time in minutes for the complete air to pas through

Inserting the above standard values into the expression, we get

$$P = \frac{501.28}{p.T}$$

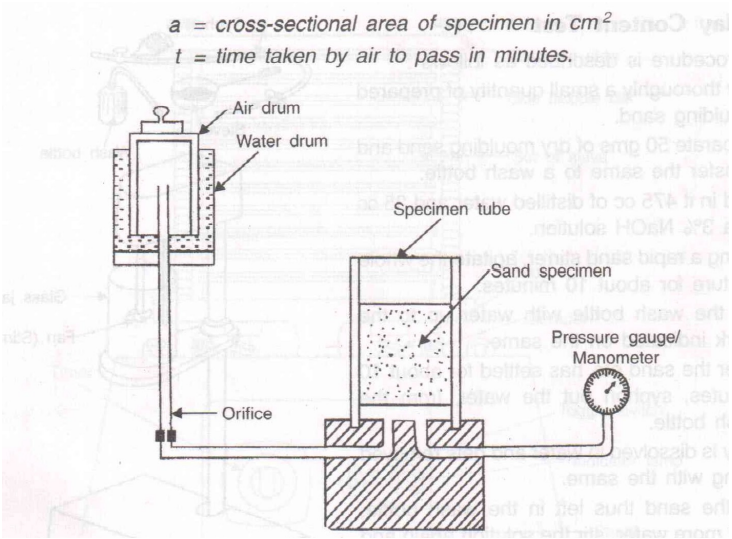

Figure 1.4.2: Permeability measuring set up

Specimen Preparation

Since the permeability of sand is dependent to a great extent, on the degree of ramming, it is necessary that the specimen be prepared under standard conditions. To get reproducible ramming conditions, a laboratory sand rammer is used along with a specimen tube. The measured amount of sand is filled in the specimen tube, and a fixed weight of 6.35 to 7.25 Kg is allowed to fall on the sand three times from a height of 50.8 ± 0.125 mm. The specimen thus produced should have a height of 50.8± 0.8 mm. To produce this size of specimen usually sand of 145 to 175 g would be required. After preparing a test sample of sand as described, 2000 cm^3 of air are passed through the sample and time taken by it to completely pass through the specimen is noted.

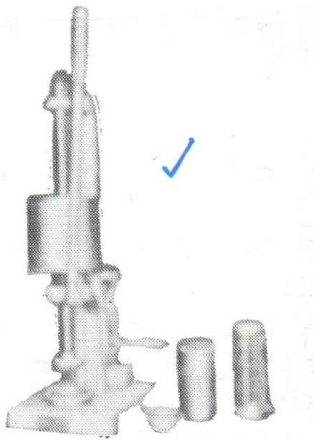

Figure 1.4.3: Sand rammer for specimen preparation

Strength

Measurement of strength of moulding sands can be carried out on the universal sand strength testing machine. The strength can be measured in compression, shear and tension. The sands that could be tested are green sand, dry sand or core sand. The compression and shear test involve the standard cylindrical specimen that was used for the permeability test.

Green Compression Strength

Green compression strength or simply green strength generally refers to the stress required to rupture the sand specimen under compressive loading. The sand specimen is taken out of the specimen tube and is immediately (any delay causes the drying of the sample which increases the strength) put on the strength testing machine and the force required to cause the compression failure is determined. The green strength of sands is generally in the range of 30 to 160 KPa.

Green Shear Strength

With a sand sample similar to the above test, a different adapter is fitted in the universal machine so that the loading now be made for the shearing of the sand sample. The stress required to shear the specimen along the axis is then represented as the green shear strength. It may vary from 10 to 50 KPa.

Dry Strength

This test uses the standard specimens dried between 105 and 110^0 C for 2 hours. Since the strength increases with drying, it may be necessary to apply larger stresses than the previous tests. The range of dry compression strengths found in moulding sands is from 140 to 1800 KPa, depending on the sand sample.

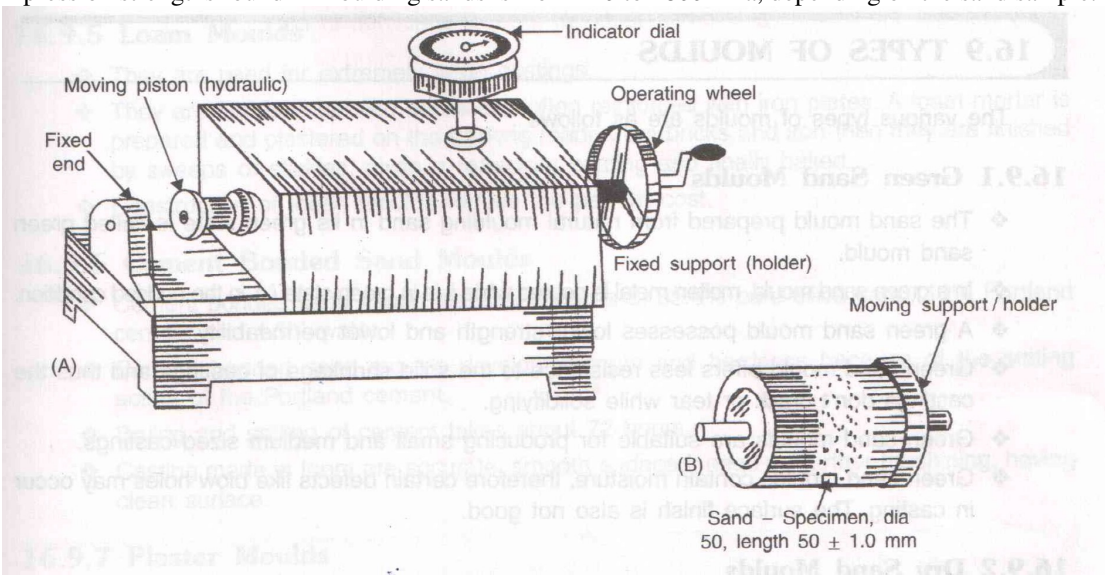

Figure 1.4.4: Sand strength testing set up

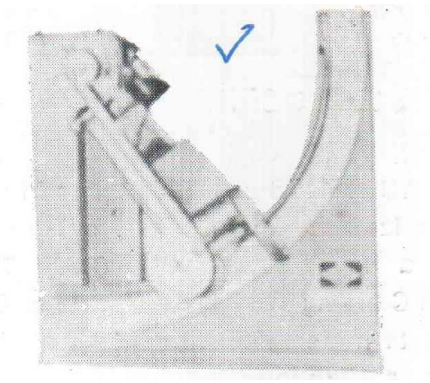

Figure 1.4.5: Universal sand strength measuring set up

Mould Hardness

The mould hardness is measured by a method similar to the Brinell hardness test. A spring loaded steel ball with a mass of 0.9 Kg is indented into the standard sand specimen prepared. The depth of indentation can be directly measured on the scale which shows units 0 to 100. When no penetration occurs, then it is a mould hardness of 100 and when it sinks completely, the reading is zero indicating a very soft mould.

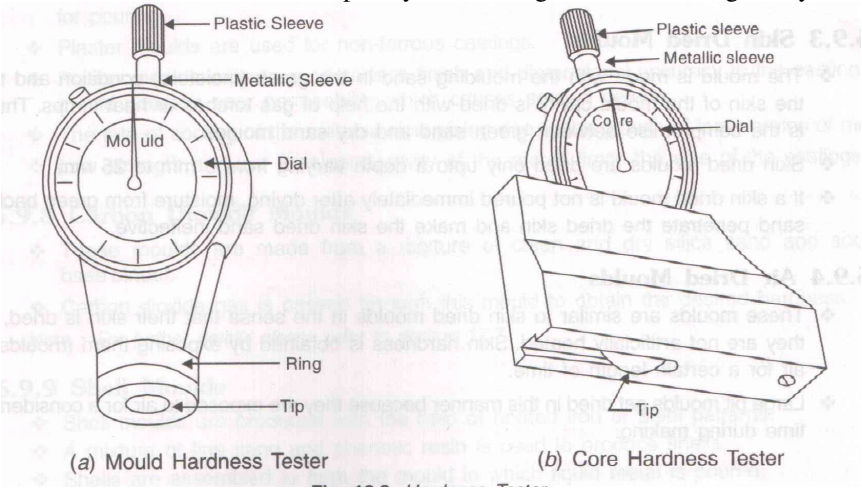

Figure 1.4.6: Mould and core hardness tester

Besides these, there are other tests to determine such properties as deformation, green tensile strength, hot strength, expansion, etc.

Reference:

1. Manufacturing Technology by P.N.Rao, TMH